�54 Bar code reader system.

�57 A reader system for optically scanning a bar code and processing the resulting video signals to produce corresponding digital signals is disclosed. The scanner comprises a camera (18) having an image sensor which converts the varying black and white bar code image into a corresponding analog video signal. This signal is fed to a dynamic threshold detector (40) which tracks the midpoint voltage value of the video signal and applies this value to a comparator (42), where it is compared to the analog video signal. The output of the comparator provides a train of logic states "0" and "1" representing video levels below and above the midpoint voltage value, respectively, thus producing a digitalized video signal corresponding to the bar code. The digital signals are filtered to mask single bit aberrations, with the filter (46) producing a series of logic "0" 's and "1" 's at the clock rate of the system, each of which represents the output of a single "pixel", or picture element, of the image sensor, the output level indicating whether the pixel has sensed a black or white bar.

The number of consecutive pixels having "0" or "1" output levels are counted (54) and compared to preset values to determine whether wide or narrow code bars are being sensed, and this information is stored in digital form in one of two serial memories (70, 72). At the same time, the total number of bars scanned is counted (84), and the memory is inhibited when the count equals the number of bars in the code.

At the completion of a first scan of the bar code image, the storage of information is switched to the other serial memory and the bar code scanning process is repeated while the data just stored in the first memory is processed, for example, in a conventional bar code-to-numeric or alphanumeric converter for display. Multiple scans of the bar code insure an accurate readout.

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FIG. I.
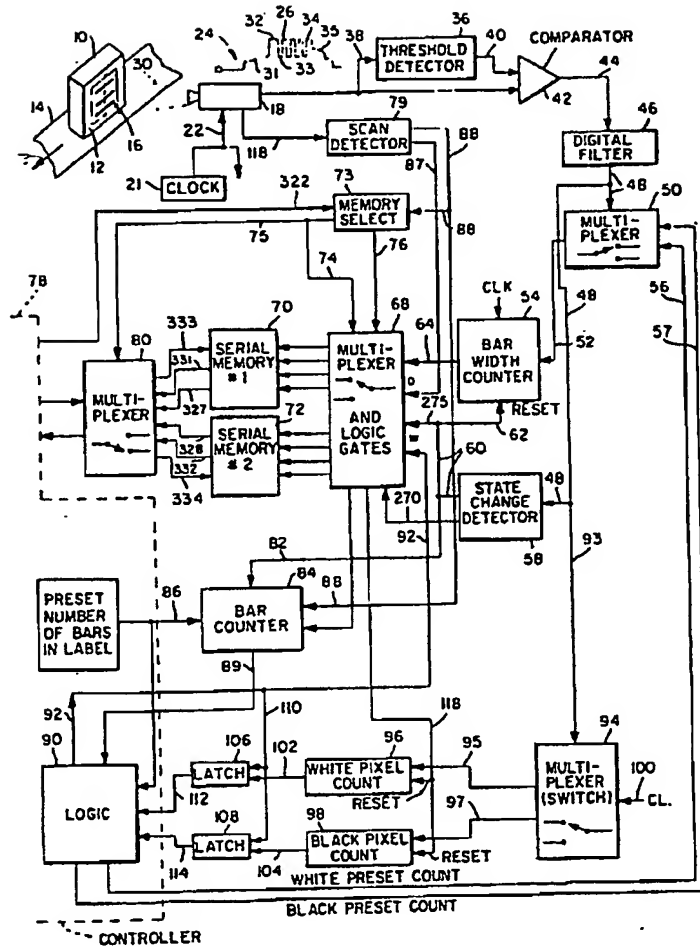
BACKGROUND OF THE INVENTION

The present invention relates, in general, to optical scanning systems and more particularly to an optical system for reading bar codes carried by moving packages such as cartons on a conveyor.

The use of optical bar codes for identifying a wide variety of goods is now well established, and such codes are commonly used for pricing, inventory control and for a variety of record keeping purposes in retail, wholesale and manufacturing operations. Such codes have proliferated with the increased use of automatic data processing systems, and this has produced a strong demand for reliable systems which will rapidly and accurately read the information provided by the codes, transfer that information to a computer, a data storage system, a read-out display, a control device, or the like. Extremely fast and accurate reading of these codes is particularly necessary if the advantages of computer control are to be realized, for although such codes may be read by a variety of available devices, or even by visual inspection, and the information then transferred to suitable data storage or handling equipment, prior art readers fail to take advantage of the high speed and accuracy of modern data processing equipment.

Numerous reading devices such as optical scanning cameras, laser systems and like optical devices, as well as a variety of mechanical systems have been developed for detecting bar codes and for providing corresponding electrical signals. Typical of the prior art systems are those shown and described in U.S. patent No. 4,135,663 to Nojiri et al., U.S. patent No. 4,136,821 to Sugiura et al., and U.S. patent No. 4,140,271 to Nojiri et al. Although such presently available bar code

readers are sufficiently accurate to be commercially valuable,
many problems are still encountered with them, and none has
been found to be entirely satisfactory. For example, many prior
devices are incapable of reading bar codes that are printed on
background material that provides a poor contrast with the
printing ink, where the printing has been done inaccurately or
incompletely, where the printing ink has been smudged, or where
dirt gets on the code label and provides false readings.

A particular problem is encountered where it is desired
to detect codes printed on moving targets such as containers on
a conveyor, for the motion of the code label compounds the prob-
lems described above. The reading of bar code labels on
conveyor-carried containers or packages presents additional
difficulties where the container can become mislocated on the
conveyor so that the label is out of focus or at an angle with
respect to the scanning camera. Thus, the container can be
twisted or tilted on the conveyor so that the code markings are
foreshortened with respect to the reader, thus making an accurate
detection of the code extremely difficult and, with many prior
art devices, substantially impossible. Because of such problems,
it becomes necessary to limit the maximum speed at which a con-
veyor can be operated and still provide some assurance of a
reasonable degree of reliability in reading the code markings,
but such a limitation prevents the user of the equipment from
realizing the benefits of high speed computerized data handling
systems, and the optical reader becomes the limiting factor in
the system. The recent introduction of laser scanners has solved
some of these problems, since lasers can be utilized to illu-
minate and scan bar code labels at high speeds and with improved
focus. But even so, even minor anomolies in the printed code on

a container or label can cause serious errors in a read-out, and this, taken with the high initial expense and the high maintenance costs of laser devices, have made such systems unsatisfactory.

5   The various problems encountered in prior art systems as outlined above have been overcome by the present invention, which provides rapid and accurate reading of bar codes at lower cost and with greater reliability than was heretofore possible. The reader of the present invention is capable of providing

10   multiple scans of a bar code as it passes by the reader at a high rate of speed, and the data handling system of the invention is capable of producing an accurate read-out of the coded information with a high degree of resolution and reliability.

SUMMARY OF THE INVENTION

15   Briefly, the reading system of the present invention utilizes a conventional line scan camera which optically scans a bar code having a plurality of narrow or wide code bars of alternate first and second contrasting optical characteristics. The coding of the bars is accomplished by means of the bar widths,

20   and accordingly it is this information which must be accurately determined by the reader. In the usual form, bar codes are printed on a contrasting background so that both the inked image and the contrasting color spaces between the printed elements can be width coded. Although a variety of color combination

25   can be used for purposes of convenience, the code bars will

The scanning camera is focused on the label to be read, and the image thereof is focused on an optical sensor. This sensor may be a charge coupled image sensor consisting of a single continuous row of photodiodes which respond to the

5 light pattern impinging thereon to produce corresponding outputs. The photodiode outputs are scanned sequentially to provide a video output signal which is an analog signal representing the output levels of each of the photodiodes in sequence. The camera repeatedly scans the bar code as it is moved past the

10 camera location to obtain a number of readouts to insure an accurate and reliable reading of the label. A threshold detector circuit responds to the peak excursions of the video output signal from the camera and produces a threshold voltage which tracks the midpoint value of the positive and negative excursions

15 of the analog video signal. This threshold voltage is compared to the original video signal in a comparator which then provides a logic 1 output for a video level which exceeds the threshold level and a logic 0 output whenever the video level falls below the threshold voltage, these logic levels occuring during the

20 scanning of white and black code bars respectively. This threshold detector thus insures the reliable detection of black and white code bars under varying ambient lighting conditions, compensates for variations in color contrast between the bar code and the package background, allows detection of faded

25 colors or improperly inked bar codes, and overcomes the problems created by a wide variety of adverse conditions that have, in the past, prevented the accurate reading of bar codes.

The output of the comparator is applied to a digital filter which eliminates logic 1 or 0 signals which have a

duration equal to that of the output from a single photodiode in the scan camera. This filter thus requires that at least two consecutive photodiodes, or picture elements (i.e., pixels) must be in the same state before that state is recognized, thereby masking any single pixel aberrations which may be found within the bar code, avoiding problems due to faulty photodiodes, and providing greater tolerance to out-of-focus conditions. The output of the filter is a series of logic 0's and 1's at the clock rate which represent the outputs of the line of pixels as sequentially scanned by the image sensor. Because of the large number of photodiodes in the camera, the outputs from a number of adjacent elements is required to indicate each black or white bar, with the exact number of pixels being dependent on whether a wide bar or a narrow bar is being scanned.

The number of black or white pixels required to represent wide and narrow bars will depend upon the exact bar code being used, as well as on the distance between the camera and the code label. To detect whether a wide or narrow bar is being scanned, the number of black or white consecutive pixels received from the filter is counted and compared to a preset value. If the series of pixels counted is below the preset value, a narrow bar is indicated, and a "0" is written into a first in-first out serial memory. If the count is greater than the preset value, but less than twice the preset value, a "1" representing a wide bar is written into the memoray so that a series of logic 1's and 0's representing the widths of the alternating white and black code bars is stored. The memory receives one input digit for each bar, and since it is known how many bars make up a code, and that the bars are alternately black and white, the only additional information required for memory storage is the width of each bar. Thus, at the completion of a scan, the memory will contain a series of logic 1's and 0's,

the value of each digit representing the width of a corres-
ponding code bar, and its location in the train representing
its color.

If the number of consecutive black or white pixels
received from the filter is greater than twice the preset value,
then the counters are cleared since such a reading indicates that
the scanner video output does not contain valid bar width data.

As the serial memory is being filled with 1's and
0's representing bar widths, the number of bars scanned by
the camera is counted and compared to a preset count representing
the total number of bars contained on the label being scanned.
A typical bar code may contain 35 code bars, and when the total
bar count is reached, the serial memory is inhibited to prevent
it from accepting further data or from being cleared.

At the completion of a first scan of the bar code,
the entire scanning process is repeated, but the information
from this second scan is fed to and stored in a second serial
memory. During the second scan, the data previously accumulated
in the first serial memory is transferred to a controller such
as a microprocessor. At the end of the second scan, the system
reverts to storing data in the first serial memory and the
process is again repeated, with the data from the second memory
being transferred to the microprocessor during the third scan.
This repetitive scanning continues until the label moves out of
the range of the scanning camera. The information from a
plurality of scans is accumulated in the computer and is
available for conversion to numeric or alphanumeric read-out
values, whereby a display of the bar code value may be provided.
Suitable error checking may also be provided to assure that
the displayed bar code value is valid, and the accumulated
data may be utilized in further processing for inventory control

or the like, as required. Such further processing is not a part
of the present invention but is conventional in the art and
will not be described herein.

At the same time each of the serial memories is being
filled with data, all white pixels and all black pixels are summed
in separate counters so that the total number of white pixels and
the total number of black pixels in a single scan is obtained.
Each of these counts is divided by the total number of white or
black bars scanned, respectively, and, since there normally is a
defined relationship between the widths, in pixels, of the wide
and narrow bars, an average width for narrow bars can be determined.
In typical bar codes, for example, a wide bar might be twice as
wide as a narrow bar. By counting the total number of white bars
and the total number of white pixels and knowing the equivalent
number of narrow bars represented by the total number of wide and
narrow bars, simple division allows a determination of the average
width of a narrow white bar. In similar manner the average width
of a narrow black bar can be obtained from the total number of
black pixels and the total number of black bars. The values so
derived are used for the preset bar widths described above.

The code reading system of the present invention thus
provides a method for optically detecting the varying black and
white code bars, converting the optical signal to a corresponding
analog video signal, digitalizing the signal by means of a thres-
hold detector to provide positive and negative signals corresponding
to the code bars, and filtering the digital signal to eliminate
aberrations. The output of the filter is then compared to preset
values representing the number of picture elements in a narrow
white or black bar to produce a digital output comprising a train
of pulses representing the width of each successive bar. The train
of pulses from each video scan is stored in one or the other of a

pair of serial memories, alternately, and the information already
stored in the memory which is not receiving data is fed to a
controller for suitable processing. In this way, the video sig-
nals representing bar codes are rapidly and accurately converted
to corresponding digital signals suitable for further data hand-
ling, and repetitive scanning of the code and accumulation of the
successive scan values insures an accurate reading of the bar
code value.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and additional objects, features and
advantages of the invention will become apparent to those of
skill in the art from a consideration of the following detailed
description thereof taken in conjunction with the accompanying
drawings, in which:

Fig. 1 is a functional block diagram of the system
of the present invention; .

Fig. 2 is a graphical illustration of a portion of
the waveform output from the scanning camera used in the
invention;

Figs. 3A-3C are a partially schematic diagram of the
circuit of the present invention;

Figs. 4A-4P are graphical illustrations of the waveforms
appearing at various parts of the diagram of Figs. 3A-3C; and

Fig. 5 illustrates the relationship of Figs. 3A-3C.

DESCRIPTION OF A PREFERRED EMBODIMENT

Turning now to a more detailed consideration of the
present invention, reference is first made to Fig. 1, which is
a functional block diagram illustrating the overall operation of
the present system. In the embodiment illustrated therein,
packages or containers 10 on which are affixed labels 12 are

carried by means of a conveyor 14 from one location to another.
For example, the containers may be boxes containing cigarette
cartons which are being delivered from a manufacturing facility
to a loading platform. The label 12 carries a bar code 16 of
conventional and well-known form, the bar code being a standard-
ized representation of information relating to the particular
container, which information is to be detected and displayed,
stored, or otherwise utilized. As illustrated, the code com-
prises a plurality of alternating black and white bars of pre-
determined widths, the preferred code being the so-called
interleaved 2 of 5 code, although the conventional UPC or other
code may be used. The bar code may be printed on a separate
label or directly on the container, and for purposes of the present
invention preferrably is arranged on the package with the bars
oriented horizontally to permit a vertical scan of the bar code
as it passes the reading station.

Located at a reading station adjacent the conveyor
is a suitable optical scanning camera 18 which, for example,
may be, a commercially available Fairchild Line Scan Camera
Model CCD1410. This camera utilizes ambient light, and thus
does not require the use of a laser, and operates by focusing
an optical image, in this case the bar code on container 10,
onto a linear array of photodiodes, each of which responds to
the portion of the image which impinges upon it to produce an
output signal. The camera electronically scans the array of
diodes to produce on line 20 an analog signal representing the
outputs from each of the picture elements in sequence. A
suitable clock source 21 drives the camera scan by way of clock
input 22 so that the output of each photodiode appears on line 20
for the duration of a single clock count, thereby producing a
wave form such as that generally indicated at 24.

An enlargement of a portion of wave form 24 is illustrated in Fig. 2, wherein it may be seen that a typical pulse 26 includes the sequential outputs from a plurality of picture elements, or pixels, each element being applied to the output line 20 for a clock time interval generally indicated at 28. The pulse 26, for purposes of illustration, represents the consecutive outputs of twelve pixels and thus may represent a wide white bar on the label 12. Since each pixel represents the output of a photodiode, the amplitude of wave 26 varies in accordance with the intensity of the light falling on the particular pixels, in accordance with the output characteristics of the particular photodiodes, and in accordance with other factors such as differences in color of the label material, imperfections in the printing of the bar code, fading of the ink, and the like. For example, if the black bars are not carefully printed, some of the ink might run into the white area and give a false reading of the widths of both bars. Furthermore, if one of the picture elements has burned out, a single count pulse might show up in the middle of another pulse, thereby producing an erroneous reading if not corrected.

The Fairchild Line Scan Camera described above includes a CCD121H line scan image sensor which incorporates 1,728 photodiode picture elements which are scanned sequentially to produce the wave form 24, the wave form thus representing a single vertical scan of the entire label 12, as indicated by the dotted scan line 30 in Fig. 1. In the present system, the camera is operated at a clock rate sufficiently high to permit multiple scans of the label as the container 10 passes by the read-out station. In accordance with one embodiment of the invention, the camera was operated at a scan rate of 560 scans

per second, which permitted consistent reading of labels at
a conveyor speed of 475 feet per minute with code bars 0.25
inches in length. By increasing the scan rate, as many as
six scans of a single label can be made at conveyor speeds of
up to 2000 feet per minute, with the multiple scans insuring
a reliable and accurate read-out.

It will be noted that waveform 24 includes a lead-
in portion 31 which represents the outputs of picture elements
responsive to an image of the portion of the carton next to
the edge of label 12. The initial pulse 32 represents a
white margin portion of the label which is wider than the
code bars, pulse 33 represents the pixel outputs from a
narrow black bar, and pulse 26 represents a wide white bar,
as discussed above. The succeeding pulses in waveform 24
represent additional black and white bars, and are followed
by another margin 34 and a trailing portion 35 which represents
the carton adjacent the opposite edge of the label. The wave-
form 24 thus represents the output from the camera in a
single scan of the label and portions of the carton on either
side of the label.

Although the amplitudes of pulses 26, 32, and 33
appear to be relatively constant, a closer inspection reveals
variations in amplitude from one scan to the next, or within
a signle scan as illustrated in Fig. 2. In order to accurately
detect the differences between the white and black pulse
amplitudes, a threshold detector 36 is provided which tracks
the average level of the video output of camera 18, and thus
tracks the midpoint of the excursions of waveform 24. This
detector thus provides an instantaneous threshold signal which

dynamically follows the midpoint of the changing video signal. This threshold value then being available for comparison with relatively positive pulses such as 32 and 26, and relatively negative pulses such as 33 to insure accurate detection of white and black code bars, even where the absolute difference in amplitude between the black and white pulses is not great. The structure and operation of the dynamic threshold detector 36 is described in greater detail in copending application Serial No.   , of Richard F. Serge and Danny D. Dugan, entitled "Dynamic Threshold Detector" and filed on even date herewith (J.T.C. Docket No. 02-76).

The video waveform on line 20 is applied to the threshold detector 36 by way of line 38, with the detector producing on output line 40 a dynamic threshold value which may be fed to a first input of comparator 42. The video signal on line 20 is supplied to the other input of the comparator, which then produces a digital output corresponding to the waveform 24. This digital output is comprised of a train of logical 0's and 1's corresponding to black and white bars, respectively, the 0's being produced when the video signal falls below the threshold value and the 1's being produced when the video signal exceeds the threshold. The length of each digital pulse corresponds to the number of clock pulses which represent the camera scanner diodes that are "looking at" the individual black or white code bar, and thus to the width of that bar.

The output of the comparator, which may be
termed a binary video output, represents the bar code
on label 12. This binary video output signal is applied
by way of line 44 to a digital filter 46 which serves

5   to eliminate waveform aberrations which are produced
by failures in individual photodiode units, by
printing imperfections in the bar code, or the like.
These aberrations generally are represented by a single
pixel variation which shows up as a pulse which

10   is a single count in length, and digital filter
46 is provided to eliminate such variations. Since
single pixel aberrations are typical, the present
invention will be described in terms of a filter
designed to mask such variations. However, it

15   should be understood that multiple pixel variations
can be masked using a filter similar to that
illustrated at 46.

Single pixel filter 46, which will be
described in detail hereinbelow, is essentially a

20   four-bit shift register which receives the binary
video signal and shifts it through to its
output in four counts.

However, the filter will only shift pulses through which are
more than one count in width, and any single count pulses are
cancelled. This function not only masks any single bit aber-
rations found in the bar code, but also provides a system which

5   is more tolerant of out-of-focus conditions, since two conse-
cutive pixels must be in the same state before that state is
recognized. Once a change in state is recognized, the filter
retroactively effects the change at the first pixel which
caused the new state.

10   The output of digital filter 46 is a series of logic
0's and 1's at the clock rate, but delayed by four counts,
which represent black and white pixels scanned by the image
sensor. This output is applied by way of line 48 to a first
bar width multiplexer circuit 50 to shift the multiplexer

15   each time the filter output changes from one logic state to
the other, i.e., each time the camera scan moves from a white
bar to a black bar or vice versa. The output from the multi-
plexer is fed by way of line 52 to a bar width counter 54 to
set the counter to a predetermined count corresponding to the num-

20   ber of pixels in, and thus the width of, either a black or a
white narrow bar, the preset counts being supplied to the
multiplexer input by way of lines 56 and 57. The multiplexer
selects one of the preset counts and supplies it to the bar
width counter 54 which then counts down under control of the

25   system clock in synchronism with the output from the digital
filter.
         The output from filter 46 is also supplied by
way of line 46 to a state change detecting circuit 58 which is
also responsive to changes on line 48 between the 0 and the 1

30   logic output levels. Each time a change of state is detected,

an output is provided by circuit 58 by way of lines 60 and 62
to set the bar width counter to its preset value. The counter
begins to count down toward zero, and if a change of state
occurs before it has counted the preset value, a 0, representing
a narrow bar, appears on counter output line 64 and is fed
through a multiplexer and logic network 68 to a selected one of
two serial memories 70 or 72. If the counter 54 reaches zero
before the change of state occurs, it resets itself and begins
to count down again. If the change of state occurs during this
second countdown, at a time that is less than twice the preset
value, a logic 1, representing a wide bar, appears on line 64
and is fed by way of the multiplexer 68 to the selected serial
memory. If the counter completes the second count before re-
ceiving the change of state signal, so that the width of the
image being scanned is at least twice the width of a narrow
bar, the signal is invalid and the counter is cleared. An
invalid signal may occur, for example, when the camera scans
the marginal "quiet zone" preceeding the bar code.

The serial memories 70 and 72 are of the first in-
first out ("fifo") type and are selected by the multiplexer/
logic circuit 68 in response to memory select signals supplied
by a select circuit 73 by way of lines 74, 75 and 76 under the
control of a suitable controller 78. This controller, which may
be a conventional microprocessor such as the Motorola M6809,
activates the memory select circuit 73 to produce a logic output
which operates to select a first one of the serial memories
during a first scan and to select the second memory during a
second scan of the label, the multiplexer shifting alternately
between the two memories for each sequential scan. This selection
may be made in response to a scan detector 79, to be described,

which response to each scan interval of the camera 18 to

provide a signal which indicates the end of a scan.

Each of the serial memories 70 and 72 is connected

through a third data output multiplexer 80 to the controller

5   78, multiplexer 80 being controlled by the memory select

signal on line 74 to alternately connect the serial memories

to the controller. When one memory is being supplied with

data through multiplexer 68, the other serial memory is connected

through multiplexer 80 to the controller for storage of data

10 from that memory and subsequent processing, to be described.

At the same time that the bar width information is

being supplied to the serial memories under control of the out-

put of the state change detector 58, the output from that detec-

tor is also being supplied by way of lines 60 and 82 to a bar

15 counter network 84 which counts the number of consecutive

bars scanned by camera 18, as represented by the change of

state pulses. A controller-supplied count of the number of

bars contained on the label being scanned is fed to counter

84 by way of line 86, and the counter is set to that number by

20 an input from scan detector 79 by way of line 88. Upon being set,

the counter 84 counts down one step each time it receives a

change of state pulse, and when it reaches zero the bar counter

produces an output on line 89 which feeds that information by way

of suitable logic circuitry 89, line 92 and multiplexer/logic

25 circuit 68 to the memories 70 and 72. This inhibits the memories

and prevents them from accepting any additional data or from

being cleared so that any information then in the selected

memory is stored for subsequent read-out.

During each scan, the output from the digital filter

30 46 is also applied by way of lines 48 and 93 to drive a fourth

multiplexer circuit 94. The outputs of multiplexer 94 are

connected by way of line 95 to a white pixel counter 96 and

by way of line 97 to a black pixel counter 98. The multiplexer

receives clock pulses from clock source 21 by way of input line

100 and feeds them to either the white pixel counter 96 or the

black pixel counter 98, depending on whether a logic 1 or a

logic 9 is present on line 93, respectively. Thus, counter 96

accumulates a count equal to the total number of white pixels

in a label scan while the counter 98 accumulates the total

number of black pixels in a scan. Upon completion of the scan

of the code bars, the bar counter output on lines 89 and 92

causes the accumulated count in each of counters 96 and 98 to

be fed by way of lines 102 and 104, respectively, to a corres-

ponding pair of latching networks 106 and 108, and the counters

are cleared. The content of the latches is then supplied to

the logic circuit 90 by way of lines 112 and 114. The logic

network 90 divides the respective white and black pixel counts

by the total number of white or black bars scanned so that average

white and black narrow bar widths are determined. These values

are then supplied by way of lines 56 and 57 to the multiplexer 50

to provide the preset values for bar width, as described herein-

above. The pixel counters 96 and 98 are reset to zero at the

end of each scan interval by means of an end of scan pulse from

scan detector 79 by way of line 87, multiplexer/logic circuit

68, and line 118.

It will be understood that the foregoing processing

occurs for each sweep of a label, and that the digital infor-

mation stored in the serial memories 70 and 72 and alternately

supplied to the controller 78 is accumulated in suitable storage

circuits and is then used to provide an alphanumeric read-out

where desired and to provide information for use in inventory

control and the like in a manner that is well known in the

art. The specific uses to which the digital representation

of the bar code data is put is a matter of choice and is not

a part of the present invention.

A more detailed illustration of the invention is

found in Figs. 3A, 3B and 3C and the wave forms of Figs. 4A

thru 4P, to which reference is now made, and wherein elements

common to Figs. 1 and 2 are similarly numbered. It should be

understood that the detailed circuitry of Fig. 3 is exemplary

of one form of the invention, and represents the best mode

presently known for carrying out the present invention.

In Fig. 3A, the container 10 is again shown as

carrying a label 12 having a bar code 16, an example of which

is illustrated in greater detail in Fig. 4A. This bar code is

of the interleaved 2 of 5 type which is preferred for the

present system, although other standard codes can be read with

the use of suitable conversion circuitry.

The bar code is, in the embodiment herein illustrated,

arranged on the container so that the bars extend horizontally,

the camera 18 scanning the bars in a vertical direction to obtain

the desired read-out. The output from the camera appears as an

analog video signal on line 20, with the wave form for a single

scan of the camera being illustrated by the solid line of Fig. 4B.

Since the scan angle which the camera is capable of covering may

be larger than the label 12, the initial part of the video output

represents the light reflected by the container 10 prior to

reaching the label. This portion of the scan is illustrated at

31 in Fig. 4B, and occurs during the time $T_0 - T_1$ of the scan

interval. When the scan reaches the label itself, the margin

area, which is the same color as the white bars or the background

material for the label, appears as the pulse 32 during time

T_1-T_2, with the first black bar producing the negative going pulse 33. As illustrated in Fig. 4B, the bar code produces during the time period T_2-T_3 alternately positive and negative going pulses which correspond to the white and black bars, thereby producing the analog wave form 24 which represents the code. At the end of the code there is another label margin portion 34, during time period T_3-T_4, followed by the portion 35 during time T_4-T_5 representing the read-out from the carton itself, which continues until the end of the scan at T_5. In a preferred form of the invention, a single video scan involves reading out in sequence each of 1,728 picture elements in the camera, with the individual pixel outputs being represented by the wave form 24 of Fig. 4B.

The output signal on line 20 is fed through resistor 138 to the positive input of a video amplifier 140, the negative input of which is connected through resistor 142 and line 144 to a ground point. The output of the amplifier is fed back to the negative input by way of line 146 and negative feedback resistor 148, and is also fed by way of line 38 to dynamic threshold detector 36. The detector tracks the midpoint value of the analog signal on line 38 to produce a voltage signal which represents the average background signal due to noise, ambient light,and the like. Such background signals are often sufficiently high to mask desired data signals, and accordingly it is necessary to distinguish this background from the modulating signals representing the data to be read. In the present case, the detector 36 tracks the D.C. signal that results from the background noise, and when the data signals due to the label bar code are reached, continues to provide an average value based on the changing amplitude data pulses. This average value

may then be used as the base line for comparison with the
video output from the camera, the outputs from black pixels
being negative with respect to the average value and the out-
puts from white pixels being positive, so that a train of
positive and negative pulses is obtained corresponding to the
bar code pattern. These pulses can be obtained accurately
and reliably even under conditions where prior devices would
not work properly, as where the amplitudes of the analog signals
vary within a single scan or from scan to scan, where the color
contrast is low, where the camera is slightly out of focus,
and like conditions.

Although threshold detectors have been suggested for
optical readers, such prior systems typically have taken an
average of the entire signal over a complete scan, the average
being derived from the prior scan rather than the current scan.
Such systems often produce an average value below the value of
the signals being detected, particularly where the signals of
interest are of low amplitude because of reduced lighting
conditions or low bar contrast, for example. When this occurs,
the variations in the signal of interest are insufficient to
produce an output from the comparator, and an invalid reading
is obtained. In the present system, however, the threshold
detector dynamically tracks the average value of the signal
currently being tracked, so that the foregoing problems are
avoided.

The threshold detector 36 includes a peak detector
and splitter network 149 which includes a forward-connected
diode 150 connecting line 38 through resistor 152 to the peak
detector network output line 154. The junction between diode
150 and resistor 152 is connected through a capacitor 156 to

ground. Similarly, the signal on line 38 is connected by way of a reverse-connected diode 160 and a resistor 162 to the output line 154, with the junction between the diode 160 and resistor 162 being connected through a second capacitor 164 to ground. In this circuit, positive going video pulses such as pulse 26 are fed through diode 150 and across capacitor 156, charging the capacitor toward the peak value of the pulse, while negative going pulses such as 33 pass through diode 160 and across capacitor 164 to charge that capacitor toward the negative value. The voltages across the two capacitors are then averaged across resistors 152 and 162 so that the net voltage on line 154 represents the average value of the positive and negative pulses 26 and 33, illustrated by wave form 166 in Fig. 4B. This value changes slightly during the course of each pulse, as indicated by the variations of line 166, and in this way the threshold value is maintained continuously and accurately at the midpoint value for the signal 24 throughout the time period T_0 to T_5.

The output signal on line 154 is applied to the positive input of a buffer amplifier 167 having a negative feedback loop 168, the buffer having an amplification factor of 1. The threshold signal from amplifier 167 is applied by way of resistor 170 to an attenuator 172 which may be a potentiometer and which divides the signal by a factor equal to the multiplication factor of amplifier 140 to restore it to the range of values of the video signal on line 20. This threshold voltage is then applied by way of the potentiometer slide arm 174 and line 40 to one input of comparator 42.

The second input to comparator 42 is the video signal 24 which is fed by way of line 20 through resistor 176 to the

second input 178 of the comparator. This comparator then

compares the two signals on a continuous basis to provide

a binary 1 output whenever the level of the video input signal

on line 178 exceeds the threshold level on line 40, and

5   provides a binary 0 signal whenever the input on line 178

falls below the value provided on line 40. Thus, the signal

appearing on line 44 is the binary video signal illustrated

in Fig. 4C and is a binary representation of the bar code.

The binary video signal on line 44 is applied to

10   the binary video digital filter 46 (Fig. 3A), which may be

best explained in conjunction with the enlarged portion 189

of waveform 24 which is illustrated in Fig. 4C'. This portion

of the waveform corresponds to a segment of the bar code

illustrated in Fig. 6, and includes a positive pulse 182

15   corresponding to a narrow white bar 184 followed by a negative

pulse 186 corresponding to a narrow black bar 188. Pulse 186

is followed by a positive pulse 190 which represents a wide

white bar 192 and a negative pulse 194 which represents a

wide black bar 196.

20   Interrupting the pulse 190 is a very narrow negative

pulse 198 which represents the output of a single picture

element. Pluse 198 is equal in duration to a single clock

pulse, the system clock being represented by the waveform 200

illustrated in Fig. 4P. This single pixel is much narrower

25   than the narrowest code bar to be detected, which typically

will be 6 pixels, and thus represents an aberration in the

camera output. Such an aberration may be caused by a spot or

mark on the bar code such as the dark spot 202 illustrated in

Fig. 6, but it should be understood that similar single pixel

aberrations may be due to a variety of causes and may appear
in either the white or the black video data pulses.

The purpose of the binary video filter 46 is to
eliminate black or white video states having a duration of
only one clock cycle such as the pulse 198 and to produce at
its output line 48 a series of logic 0's and 1's at the clock
rate, but delayed by four counts, which represent plural black
and white pixels as scanned by the image sensor. Such a
filtered signal is illustrated in Fig. 4L by the wave form 204.
The binary filter includes a four-bit shift register 206 which
may, for example, be a conventional 7495 integrated circuit.
The unfiltered binary video signal on line 44 is fed to the
series input terminal 208 of the shift register and by way of
line 210 to load input A, which is one of four parallel inputs
A, B, C and D. The system clock 21, which produces the wave
form illustrated in Fig. 4P, supplies clock pulses by way of
line 22 to the shift and load input terminals 214 and 216,
respectively, of the register 206. The clock pulses operate
to sequentially shift the signals on the serial input line 208,
or on the load input lines A, B, C or D, to the parallel output
lines QA, QB, QC and QD, the particular signals being shifted
depending on the mode of register 206. The register may be
shifted between its serial and parallel modes by means of
signals applied to the mode input terminal 218.

Register output QA is connected by way of output
terminal 220 and line 222 to the load input terminals 224 and
226 leading to load inputs B and C. This connection insures
that whenever the register is in its parallel mode, any output
appearing on output QA is shifted into the input stages B and
C. Output QB is unconnected, while output QC is connected by

way of terminal 228 and line 230 to one input of an exclusive
OR gate 232, the other input of which is supplied from terminal
220 of the output QA by way of line 234. Output QC is also
connected by way of terminal 228 and line 236 to load input
D by way of terminal 238. Out QD provides on terminal 240
the filtered binary video signal 204 (Fig. 4L) which is
supplied to line 48.

The output of gate 232 is connected by way of
line 242 thru inverter 244 to the mode shift terminal 218.
Whenever output QA is the same as output QC, gate 232 goes to
zero and the inverter 244 output goes to 1 to provide a signal
to the mode input terminal 218 to shift the register to the
parallel mode. When the outputs on QA and QC are different
the output of gate 232 goes to 1, the output of inverter 244
goes to 0, and the register remains in the serial input mode.

The operation of the filter 46 may be explained with
reference to waveforms 180 and 204 in Figs. 4C' and 4L, assuming
that at time T_N the positive going pulse 182 is applied by way
of line 44 to the shift register 206. It is assumed that prior to
time T_N the register has been loaded with a binary 0 so that all
of the outputs QA thru QD carry 0's. Because QA and QC are the
same, the mode input terminal 218 is activated and the register
is loaded in parallel from the inputs A, B, C and D, and the
output line 48 carries a 0. At time T_N, a binary 1 (the first
pixel of pulse 182) is applied to the register and is fed by way
of terminals 208 and 210 to the serial input SI and to the load
input A, thereby shifting the output on QA to a 1, generating 1 at
the output of gate 232, and allowing the register to return to the
serial input mode. At the occurrence of the next clock pulse,
which occurs at time T_N+1, the 1 signal on QA is shifted to QB
and a 1 is supplied from the input SI to terminal QA so that a 1

now appears on output terminals QA and QB, while 0 outputs
remain on QC and QD. At time T_N+3, another 1 input is applied
to terminal 208, shifting the output so that 1's now appear
at output terminals QA, QB and QC. Terminal QD remains at

0. With QA and QC now both carrying 1's, the output of OR
gate 232 shifts to 0 and the register 206 is shifted to the
parallel mode, whereby the output signal on QA is fed by way
of line 222 to the parallel inputs B and C to insure that QA,
QB and QC are all the same. Since QB and QC already were the

10   same as QA, this effects no change in the register. The output
on QC is fed by way of line 236 to input D at terminal 238 so
that upon the next shift of the register, output QD will go
to 1. At time T_N+3, then, another 1 is applied to the shift
register input and all of the outputs QA and QD carry 1's. The

15   1 now appearing at QD appears as the leading edge of pulse
182' on line 48, and is delayed by four counts.

At time T_N+6, the process repeats itself, with the
outputs of the shift register sequentially returning to 0
until at time T_N+10 pulse 182' goes to 0 on line 48.

20   At time T_N+12, a 1 is applied to the input of the
shift register by way of line 44 and the process again repeats
itself until at time T_N+16 the outputs QA thru QD all carry
1's, and pulse 190' appears on output line 48. However, pulse
T_N+16 is a 0, representing an aberration in the bar code and

25   the application of this 0 causes a 0 to appear on output QA,
thereby generating a 1 at the output of gate 232 and shifting
the register back to the serial mode. At time T_N+17, the input
pulse shifts back to a 1, and the 0 is shifted to output QB. At
this time, outputs QA and QC are both 1's, and the gate 232 is

30   reactivated to shift the register to the parallel mode. This
causes the signal on output QA to be fed by way of line 222 to

the load inputs B and C. Since the register is in the parallel

mode, this forces output QB to change to a 1. At time T_N+18,

another 1 is inserted into the register, the 1 now appearing at

the output QB is shifted to QC, and the system continues as

5   before. However, the aberration represented by pulse 198 has

now been eliminated, since it was only one pixel in duration

and, as may be seen in waveform 190', that aberration never

reaches the output terminal 240 of the register, and thus never

appears on line 48. In this way, the filter eliminates pulses

10   that are only a single pixel wide and requires information

signals to be at least two pixels wide if they are to pass through

the filter. This serves to eliminate a large number of false

readings, and increases the reliability of the system.

Although the operation of filter 46 has been described

15   for a single pixel aberration, it will be understood that such

filters may be provided for aberrations greater than one pixel

in width. In such cases, the shift register 206 will be of

greater capacity, with the exact length of the register depending

upon the number of pixels to be masked, but following the techni-

20   que outlined above. Such multiple pixel filters may be required

in high noise applications, but for most purposes a single pixel

filter as described provides reliable operation of the system.

The output signal on line 48 from the binary video

filter is a series of logic 0's and 1's at the clock rate,

25   but delayed by four counts, which represent black and white

pixels as scanned by the image sensor, and as illustrated by

waveform 204. This wave is applied by way of line 48 through

a resistor 252 to one input of an exclusive OR gate 254, and

by way of line 256 to the other input of gate 254. A capacitor

30   258 is connected to the junction between resistor 252 and gate

254. This circuit responds to each change of state in waveform

204 (i.e., from a 1 to a 0 logic state, or vice versa) to produce an output pulse on line 260 which is applied to the input of a one-shot multivibrator 262. This pulse activates the one-shot to produce a single output spike 264 on line 60, this output being illustrated in Fig. 4M. Thus, the output of one-shot multivibrator 262 is a series of spikes 264 on line 60, each spike coinciding with a change in the logic state of the signal on line 48.

The output signal from one-shot 262 is applied by way of line 266 to the input of a second one-shot multivibrator 268 to activate that circuit to produce on its output line 270 a string of output pulses 272, illustrated in Fig. 4N. Again, the pulses 272 are produced at the end of each of the positive and negative going pulses in waveform 204. The train of pulses 264 which appears on line 60 is supplied to the bar width counter 54 by way of line 62, OR gate 273, and line 274, is supplied to the multiplexer and logic gates 68 by way of line 275, and is supplied to the bar counter 84 by way of line 82. The train of pulses 272 which appears on line 270 is applied to logic networks to be described within the multiplexer logic circuit 68.

The pulse train on line 60 which is applied to the bar width counter 54 serves to reset that counter at the end of each of the 0 and 1 pulses of waveform 204 to provide a count in pixels or in clock pulses of the width of each pulse and thus the width of the corresponding code bar being scanned. The bar width counter output on line 64 is applied to the multiplexer and logic gate circuit 68 to provide a data pulse to the serial memories 70 and 72 to store bar width information. The same signal from line 60 is also applied to the bar counter 84 by way of line 82 to cause that circuit to count the number of

code bars read in each scan so that the serial memories are
disabled when the total number of bars on the label has been read.

The bar width counter 54 receives at the beginning
of each scan a present count equal to the maximum number of
pixels which will represent a narrow bar for the particular
label and camera location. This information is provided
through the multiplexer 50 which alternately supplies the
required count for white bars and black bars and is switched
from one to the other by the waveform 204 appearing on line 48.
A positive pulse, such as the pulse 182', switches the multiplexer
to the predetermined count set on its inputs 1A through 4A by
way of line 56, which count represents the width of a narrow
white bar, while negative pulses, such as pulse 186', switch
the multiplexer to the values supplied to input terminals 1B
through 4B by way of line 58. These counts are transferred to
the bar width counter 54 when it is reset by pulses 264, and
the counter is then stepped down by the system clock. It will
be understood that the values supplied to the multiplexer 50 by
way of lines 56 and 58 are preset by the controller 78 and are
established before commencing label reading operations.

The narrow bar counts supplied to the bar width
counter are a function of the particular label being used and
the distance between the scanning camera and the label being
read. The count values are generally established in the system
design, when the label size and camera location are known. Even
when these parameters are known, however, there will be variations
which can affect the bar count value. For example, if the camera
is located closer to the label, or further away, than the design
value, the number of pixels representing a code bar will vary
from the predetermined value. To accomodate this, the controller
78 provides an initial count which will be a "good guess" for

camera locations within a range of, for example, two to
four feet. This "good guess" value is used as the count
for the first label, and the system then corrects itself
by means of the pixel counters 96 and 98 to provide
accurate maximum narrow bar counts, as will be
described.

Additional flexibility may be provided in
the system by providing means (not shown) for enabling
an operator to provide an initial "good guess" value
based on inspection of the particular label and camera
configuration. Such an arrangement would also make
use of the pixel counters and associated circuiting
to correct the initial guess and to provide accurate
count values.

When the appropriate count is supplied to the
bar width counter 54 by the multiplexer 50, a pulse from
the state change detector 58 is applied by way of line
274 to reset the counter 54, which then starts counting
down under the control of the system clock. When the
counter reaches 0, a pulse appears on counter output
line 276, and this signal is fed through an inverter 278
to produce a logic 0 pulse on line 64. This logic 0 is
applied to the second input of OR gate 273 to reset
the bar width counter so that it will start counting
down again, and is also applied to the clock inputs
of a two stage shift register 282, which is part
of the multiplexer and logic gate circuit 68

and which incorporates a pair of flip-flops 283 and 284. The
shift register has a logic 1 signal applied to the data ter-
minal 285 of flip-flop 283 so that when it is clocked by the
pulse on line 64 the output on line 286 goes to 1. Since the
pulse on line 64 only occurs after the bar width counter 54
has reached 0, the presence of such a pulse indicates that the
predetermined maximum pixel value for a narrow bar has been
exceeded and that, therefore, the bar being scanned is a wide
bar. Thus, the appearance of a logic 1 on line 286, illustrated
by pulse 288 in Fig. 40, is indicative of a wide bar. As may be
seen in Fig. 40, the pulse 288 occurs whenever a wide bar is
sensed, without regard to whether it is a white or a black bar.

If the code bar being sensed is narrow, the state
change detector 58 produces an output on line 60 which resets
the bar width counter 54 before it reaches 0, thus preventing
a pulse from reaching line 64, and output line 286 from the two
stage shift register remains at 0. It will be noted that the
state change detector 58 also produces an output on line 270
which resets the shift register 282 each time the binary video
signal shifts from one logic state to the other, thereby
returning the output signal on line 286 to 0 at the end of each
binary video pulse.

The data pulses 288 are supplied by way of line 286
to the data input terminals 288 and 290 of serial memories 70
and 72 (Figs. 3B), respectively. These memories store the
received data in a serial manner for later transfer to suitable
data processing circuitry. Control of the memories is effected
by a logic circuit which includes first and second AND gates
292 and 294 connected to the clock and reset terminals 296 and
298, respectively, of memory 70, and AND gates 300 and 302 which

are connected to the clock and reset terminals 304 and 306,

respectively, of memory 72. The output from AND gate 294

is connected to terminal 298 through an inverter 308, while

AND gate 302 is connected to terminal 306 through an inverter
310.

As previously indicated, data is supplied to only

one of the memories 70 and 72 at a time, during which time

the data already stored in the other memory is transferred out.

Selection of the memory circuits for storage of data is

accomplished by means of a memory select flip-flop circuit 73

which is provided with a data input from controller 78 by way

of input terminal 322 and which is driven by end of scan pulses

on line 88 to produce an output on line 76 which alternates

between a logic 1 and a logic 0 for each scan of the camera 18.

The output on line 76 is illustrated in Fig. 4J by waveform

324 which is at logic 1 for the first scan, and then shifts to

logic 0 for the next following scan.

The flip-flop 73 produces a second output on line 74

which is illustrated by waveform 326 in Fig. 4K. As shown,

the signal on line 74 is of opposite polarity to the signal on

line 76, with the polarities being shifted by the periodic inputs

on line 322 from controller 78. The waveform 326 on line 74

is applied to the AND gates 292 and 294 which control memory 70

to enable these gates when a logic 1 signal is applied thereto.

Similarly, the wave form 324 on line 76 is applied to AND gates

300 and 302 to enable these gates upon application of a logic 1.

The state of flip-flop 73 thus permits selection of only one of

the memories for storage of data.

The output signal on line 74 is also applied by way of

line 75 to multiplexer 80, the multiplexer receiving output signals from

memories 70 and 72 by way of lines 327 and 328 and transferring

those signals to both of its output lines 329 and 330. The

multiplexer is shifted by waveform 326 to receive data from

memory 72 during the scan interval when data is being stored

in memory 70, and to receive data from memory 70 during the

scan interval when data is being sotred in memory 72. The

memories 70 and 72 are also connected to the multiplexer by way

of "output ready" lines 331 and 332 which are status lines to

indicate when data is available to be read out. If no data is

available, an output signal is fed to the controller by way

of multiplexer output line 330.

The transfer of data is effected by way of "shift

out" input lines 333 and 334 connected to the memories 70 and 72.

These lines carry strobe pulses which are supplied by the controller

78 at the clock rate by way of line 335, inverter 336, and line

337 to the multiplexer for application to whichever of the

memories is selected to transfer data out. The number of strobe

pulses provided by the controller during each scan cycle corres-

ponds to the number of code bars on the label being read, and

thus to the number of storage locations in the memories used

for the holding of the bar code data. Each strobe pulse is

fed to the memory selected for readout, and the leading edges

of the pulses clock the data serially out of one storage location

of the memory after another. The data from each location is

transferred through the multiplexer to its output lines 329 and

330 and to corresponding flip-flops 338 and 339. The data may

be transferred to both flip-flops, for redundant temporary

storage, or, if the flip-flops are connected through the multi-

plexer to a specific memory, may be fed to one or the other,

depending on which memory is selected. The leading edge of

each strobe pulse advances the memory to the next storage

location as it clocks the data out, so that the next memory
location is read by the next following strobe pulse.

The strobe pulse on line 337 is applied to the clock
inputs of flip-flops 338 and 339 by way of line 340, and the
strobe pulse on line 335 is applied to gated buffers 341 and
342 by way of lines 343 and 344. These buffers are connected
to the outputs of flip-flops 338 and 339, respectively, by
way of lines 345 and 346 to connect the flip-flops to the
controller 78. The trailing edge of the strobe pulse clocks
the flip-flops 338 and 39 and enables the buffers 341 and 342
to cause the data in both flip-flips to be clocked through the
buffers to the controller for processing. In this way, data
is transferred from the selected memory and latched in the flip-
flops while the memory is advanced, and then the data is
transferred out of the flip-flops.

The scan detector 79 is illustrated in greater detail
in Fig. 3C, wherein it is shown as receiving from a video out-
put terminal 350 on camera 18 a waveform such as that illustrated
in Fig. 4D. The camera circuitry thus produces a periodic
video gate pulse 352 which occurs during the blanking interval
at the end of each scan. This gate pulse is applied by way
of line 118 to the scan detector 79, which comprises a pair
of one-shot multivibrators 354 and 356 which are driven by
pulse 352 to produce their output lines 87 and 88 the end of
scan pulses 358 and 360 illustrated in Figs. 4E and 4F, re-
spectively. The one-shot multivibrators produce very narrow
pulses which are applied to the logic circuits 68 and 73 to
control the flow of data into the memories 70 and 72.

The pulse on line 88 from scan detector 79 is sup-
plied to the clock input of memory select flip-flop 73 to cause

that flip-flop to change states during the scan interval, i.e.,
between successive scans, thereby enabling the memories 70 and
72 to shift. The output on line 87 is applied to the multiplexer
and logic circuit 68, and more particularly to one input of an
OR gate 362 (Fig. 3A). The other input to this gate is derived
from output line 364 from flip-flop 284 of the two stage shift
register 282, the signal on line 364 being illustrated in Fig.
4G as waveform 366. This signal is a 1 at the margin areas of
the bar code, is a 0 during the portion of the video scan where
the bar code is being read, and returns to 1 at the end of the
bar code, the output on line 364 being determined by the value
of the output from flip-flop 283, which is supplied to the data
input of flip-flop 284 by way of line 367. Flip-flops 283 and
284 are driven by the bar width counter 54 by way of line 64,
thereby providing margin signals on line 364 for application to
gate 362. When either the positive-going margin signal on line
364 or the end of scan pulse 358 on line 87 is applied to OR gate
362, an output is supplied to line 368 which is fed through
inverter 369 for application by way of line 370 to one input
of an AND gate 372 (Fig. 3B) to reset the memories 70 and 72, as
will be described more fully below. The output from inverter
369 is also applied by way of line 370 and line 118 to the pixel
counters 96 and 98 to signal the end of the scan interval.

Resetting of the memories 70 and 72 occurs as follows.
When the bar width counter 54 counts down to 0 and produces
a carry pulse on line 276, the resulting negative pulse on
line 64 is fed to the clock inputs of flip-flops 283 and 284
in the two-stage shift register 282. The first clock pulse
shifts the output on line 286 to a logic 1 to indicate a wide
bar. At the same time, the carry pulse is applied by way of

line 280 and OR gate 273 to reset counter 54 so that it again

counts down. If it again counts down to 0 before being reset

by the state change detector 58, a second carry pulse will be

produced on line 276 which will again be applied by way of line

5   64 to the clock inputs of flip-flops 283 and 284. This time,

however, a 1 has been applied to the data input of flip-flop 284

from line 286 by way of line 367, thereby shifting the output on

line 364 to a logic 1. When this occurs it indicates that the

normal width of a wide bar has been exceeded, thus indicating that

10   the scanner is at the margin of the label, if off the label, or is

reading an invalid bar. The output on line 364 thus is a margin

signal which is applied through gates 362 and 369 to gate 372,

which produces a memory.reset signal on its output line 374 to

activate AND gates 294 and 302. One of these gates has already been

15   enabled by a memory select signal on either line 74 or 76, so that

a signal is provided to the reset input of whichever of the mem-

ories 70 and 72 is then being selected. Thus, if the memory

select flip-flop 73 has enabled gates 292 and 294 so that memory

70 is receiving bar code data, then AND gate 294 produces an out-

20   put to reset that memory, since the data being supplied is

invalid. At the same time, since memory 72 has not been selected,

gates 300 and 302 are not enabled by the flip-flop 73, and the

output from gate 372 does not reset that memory, thus allowing

data transfer out of memory 72 to continue.

25   The margin signal on line 364 is also applied by way

of line 380 to OR gate 382 to clear the bar counter 84. This is

accomplished by an output signal from gate 382 which is applied to

the clear terminals of four-bit up-down counters 384 and 386 by

way of lines 388 and 390. It will be noted that the output from

30   scan detector 79 also is applied to the clear terminals of counters 384 and

386 by way of line 88 and OR gate 382, so that the bar counter is reset to 0

at the end of each scan interval, if it is not cleared by a margin signal first.

The output of the bar counter 84 provides the second
memory reset input ot OR gate 372 (Fig. 3B) by way of line
92. The bar counter 84 is preset by the controller 78 to the
total number of white and black bars in a given label, the
particular number being determined prior to the counting process
depending upon the particular bar code being used. This number
is preset into the counter 84 by way of input line 86, and the
counter then proceeds to count down under control of the state
change detector output pulses 264 (Fig. 4M) on lines 60 and 82.
If the selected code uses 35 bars, for example the counter will
be preset to 35, and upon receipt of 35 pulses the bar counter
will produce an output pulse on line 392. This pulse, indicated
in Fig. 4H at 394, coincides with the scanning of the last bar
in the code and is applied through gate 396 and line 89 to a
suitable flip-flop circuit in the controller logic 90 which
responds to produce a memory inhibit signal on line 398. This
signal is fed through an inverter 400 and appears on line 92
as the waveform 402 illustrated in Fig. 4I. As illustrated,
the signal on line 92 is a logic 1 until the bar counter 84
complete its count, at which time it drops to a logic 0. When
this signal drops to 0, the AND gates 292 and 300 in the logic
circuit 68 (Fig. 3B) are disabled so that pulses on output lines
60 and 275 of the state change detector 58 can no longer reach
either memory 70 or 72. Since the pulses 264 (Fig. 4M) acted
as the clock pulses for the memories to shift into the memory
the logic values on data input line 286, the disabling of
gates 292 and 300 disables the memories and prevents insertion
of additional data. Further the inhibit pulse on line 92 is
applied to AND gate 372, disabling that gate and thereby
disabling the reset gates 294 and 302 to prevent the

memory circuits 70 and 72 from being reset. The memory

reset circuits are held in their disabled condition by the bar

counter 84 until the scan detector produces an end of scan

pulse which clears the bar counter for the next scan interval.

5   It will be noted that the bar counter 84 is cleared

by the margin immediately preceeding the bar code so that an

accurate count is obtained and is again reset at the end of

the bar count by the margin signal on line 83 or by the end

of scan signal on line 126.

10   As previously indicated, the maximum number of

picture elements, or pixels, which represent the width of a

narrow bar is variable, and will depend upon the size of the

label, on the distance of the camera from the container on which

the label is located, and on other factors. Thus, to begin

15   operation of the system, narrow bar counts for both black and

white bars initially established by the system as a "best guess".

These counts, which may be different, are supplied to the multi-

plexer 50 which then alternates between the black and white

values to provide the correct count to the bar width counter 54,

20   as previously described. In order to insure accuracy of the

system, however, the "best guess" values are corrected to the

actual values by means of pixel counters 96 and 98. Each of

counters 96 and 98 includes a pair of four-bit up-down counters,

the white pixel counter 96 including counter circuits 410 and

25   412 and the black pixel counter 98 including counter circuits

414 and 416. Counting of black and white pixels is under the

control of the filtered binary video signal on line 48, which is

applied by way of line 93 to the AND gates 422 and 424 which

make up multiplexer 94. The signal on line 93 comprises binary

30   1's and 0's alternating in accordance wiht the black and

white code bars, and these signals are applied from line 93 through an inverter 426 to one input of AND gate 422 and through line 428 to one input of AND gate 424 to alternately enable these gates. The second input to each of the AND gates is a clock signal derived from the system clock and supplied by way of input line 100.

The clock pulses on line 100 are fed through whichever of the AND gates is enabled by the binary video signal, and are applied to either the white pixel counter 96 by way of line 95 or the black pixel counter 98 by way of line 97, thereby driving the counters 410, 412 or 414, 416. The pixel counters are cleared only at the end of a scan or upon occurrence of a margin pulse on line 370, which is applied to the counters by way of line 118. Therefore, the counters 96 and 98 provide a total count for the white pixels activated during a complete scan and also provide a total count for the black pixels activated during that scan. These total counts are applied by way of lines 102 and 104 to the latching networks 107 and 108 for temporary storage, the latches being activated upon the occurrence of the output pulse 394 (Fig. 4H) from the bar counter 84 which signals the completion of the bar code scan. This signal is applied from line 92 by way of line 110 and inverter 430 to the respective latching networks by way of lines 432 and 434, the occurrence of this latching signal preventing additional counts from entering the latch networks from counters 96 and 98. At this time there appears on latch outputs 112 and 114 counts equal to the total numbers of white and black pixels, respectively, activated during the course of a single scan, and these counts are supplied to suitable comparison circuitry within the controller 78, such as logic circuitry 90, where the total number of pixels is divided by the number of bars in the label to produce new narrow bar maximum values for application to the multiplexer 50. These new values are used as the nominal width values for the black and the white bars during the next scan.

In summary, then, the camera 18 scans the bar
code 16 carried on label 12 to produce an analog output
signal which represents the light intensity striking each of
the 1,728 picture elements in sequence in the camera scanner.

5   A single scan requires 1,728 clock pulses, and a single scan
interval thus includes that number of counts. As illustrated
in Fig. 4B, however, a part of the scan may cover some of the
container surface adjacent the label and will cover margin areas
adjacent the code bars to produce margin signals which preceed

10   and follow the data of interest.

A. theshold detector tracks the video signal from the
camera to automatically vary the threshold in accordance with
ambient light, background color, variations in lenses, and the
like, so that when the data representing the bar code is reached,

15   the threshold is at the D.C. level of the background and ac-
curate readings can be obtained for the positive and negative
signals representing white and black bars. The threshold value
is compared to the analog output signal in a comparator, and
an accurate binary video signal is obtained. This binary signal

20   is fed through a digital filter which eliminates single pixel
aberrations and the resultant filtered signal is applied by way
of a change of state detector and suitable logic gates to
control the application of data from one or the other of a pair
of memories. Two memories are provided so that while one is

25   receiving data relating the the current video scan, data re-
lating to the next preceeding video scan, already stored in the
other memory, can be transferred to suitable storage and data
handling circuits.

The data supplied to the memories is in the form of

30   a single logic 0 or logic 1 signal occurring during each white or

black bar read-out. Since it is known that white and black bars alternate in the bar code, it is not necessary to store in the memory data representing the black and white pulses; the code always starts with a black bar, and thus as soon as the code read-out begins after the margin reset occurs, it is known that the first interval will represent a black bar, the next interval will represent a white bar, and so on. The only information lacking, therefore, relates to the width of the bar, and this is supplied by the bar width counter which produces an output only when a wide bar is encountered. When a wide black or white bar is encountered, therefore, an output data pulse is supplied to the selected memory. Accordingly, the memory stores a series of 0 or 1 logic states, the 0 states representing black or white narrow bars, and the 1 states representing the occurrence of a wide bar.

To prevent errors, the bar width counter is recycled so that if the measured bar is too wide, a second pulse output resets the memory. Such a reset indicates that the camera is scanning a margin or that the bar code is invalid.

As a further protection against error, a bar number counter is also provided and produces an output pulse when the preselected number of black and white bars have been counted. This counter is preset to the known total number of bars on a label and produces an inhibit signal at the end of the pre-selected count to prevent the insertion of additional data to the memories. The bar number counter is reset by the margin indicating pulses as well as by pulses indicating the end of a scan interval.

Because of variations in the apparent width of the bars on a label, due to variations in the distance between the camera

and the label being scanned, the bar width counter must be
adjusted to a particular camera setup. This is accomplished
by preliminarily establishing a maximum value for bar width,
and then updating that approximation by means of an actual

5   count. This actual count is obtained by means of a totaling
counter which is operated by the system clock to count the
total number of white and black picture elements, or pixels,
in a label code. These pixel counters are reset by the margin
signal preceeding the code, and then proceed to count the total

10   number of pixels, with the count being fed directly to corres-
ponding latch circuits. As soon as the bar number counter
indicates that all of the bars have been counted, the latch
circuits are activated to hold the count, and the resulting
sums are then divided by the known number of bars in the label

15   to provide average maximum values for the narrow bars, which
values are then automatically substituted for the initial
approximations for use in subsequent readings.

Although the present invention has been directed in
terms of a preferred embodiment thereof, it will be apparent

20   to those of skill in the art that numerous variations and
modifications can be made without departing from the true spirit
and scope thereof as defined in the following claims.

WHAT IS CLAIMED IS:

1. An optical reader system for bar codes,

having narrow and wide code bars of first and second

3   contrasting optical characteristics, said system comprising;

means for optically scanning a bar code and for

5   producing an analog video signal corresponding to .the bar

code image;

7   means for converting said analog video signal to

a binary video signal;

9   · filter means for eliminating aberrations in said ·

binary video signal to produce a filtered binary signal;

11 means responsive to changes in the state of said

filtered binary signal for producing a train of bar width

13. signals corresponding to the widths of successive code bars;

first logic means responsive to said bar width

15 signals for producing digital data signals corresponding to

said bar code;

17 digital memory means for serially receiving and

storing said digital data signals; and

19   second logic means for selectively inhibiting

and clearing said memory means, whereby data relating to

21   only a single bar code at a time is entered in said

memory means.

2. The system of claim 1, wherein said means for

scanning comprises a line scanner having a plurality of

3   picture elements each responsive to that portion of the

image of said bar code which impinges thereon to produce a

5   corresponding electrical output signal, or pixel, and means

for sequentially scanning said pixels to produce an analog

7   video signal consisting of a series of pixels.

3. The system of claim 2, wherein said bar code

comprises a series of width-coded bars of alternating optical

3   characteristics, and wherein the image of each of said code

bars impinges on at least two adjacent picture elements, whereby

5   said analog video signal comprises a train of pulses each at

least two pixels wide.

4. The system of claim 3, wherein said means for

converting said analog video signal to a binary video signal

comprises:

dynamic threshold detector means responsive to

said analog video signal to produce a D.C. threshold signal

which is equal to the average value of said analog video

signal; and

comparator means for producing a binary video

signal equal to the difference between said threshold signal

and said analog video signal, said binary video signal

comprising a series of pulses having a first amplitude

corresponding to code bars of a first optical characteristic

and having a second amplitude corresponding to code bars of

a second optical characteristic, each of said pulses having a

width corresponding to the number of pixels impinged by the

image of the corresponding code bar.

5. The system of claim 3, wherein said filter means

includes means for masking predetermined pixel variations in said

binary video signal.

6. The system of claim 5, wherein said filter means comprises a shift register having serial and parallel input means for receiving said binary video signal, means for shifting said binary video signal through said shift register a single pixel at a time to provide a delayed output, and means responsive to a preselected pixel variation to change the shift register from a serial input mode to a parallel input mode to prevent said pixel variation from reaching said shift register output.

7. The system of claim 3, wherein said means for producing a train of bar width signals comprises:

a state change detector connected to the output of said filter means for producing a state change pulse each time said filtered binary signal changes from one binary state to another; and

a bar width counter responsive to said state change pulses to produce said bar width signals.

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8. The system of claim 7, wherein said means

for producing a train of bar width signals further

3   comprises:

        means for supplying to said bar width counter

5   predetermined counts equal to the maximum number of pixels

    produced by a narrow code bar of each of said contrasting

7   optical characteristics, said bar width counter stepping

    down one count for each pixel scanned and producing a first

9   bar width pulse at the end of a count; and

        means responsive to said state change pulse or to

11 a bar width pulse from said bar width counter for resetting

    said bar width counter, said bar width counter being reset

13 by said state change pulse before a bar width pulse is

    produced whenever a narrow code bar is being scanned, and

15 said bar width counter being reset by said first bar width

    pulse and thereafter by said state change pulse whenever a

17 wide code bar is being scanned.

9. The system of claim 8, wherein said first

logic means comprises multiplexer means connected to said

3   bar width counter and to said state change detector, said

multiplexer means being driven by said bar width pulses and

5   said state change pulses to produce digital data signals

comprising a first digital output level for each narrow code

7   bar scanned and a second digital output level for each wide

code bar scanned.

10. The system of claim 9, wherein said digital

memory means is connected directly to said multiplexer

3   means to receive and store said digital data signals.

11. The system of claim 7, further including:

bar counter means for producing a bar count pulse

3   when a predetermined number of code bars have been scanned;

and

5   means responsive to a bar count pulse to activate

said second logic means to inhibit said memory means.

12. The system of claim 11, further including

means for presetting said bar counter to the number of bars

3   in the bar code to be read, said bar counter means being

driven by said state change pulses to count the number of

5   bars scanned, said bar counter producing said bar count

pulse when the number of state change pulses received equals

7   the preset number of bars.

13. The system of claim 7, wherein said means for

producing a train of bar width signals comprises:

3   means for supplying to said bar width counter

predetermined counts equal to the maximum number of pixels

5   produced by a narrow code bar of each of said contrasting

optical characteristics; and

7   means for updating said predetermined bar width

counts.

14. The system of claim 13, wherein said means for

updating comprises:

3   first and second pixel counters for counting the

total number of pixels representing the total number of code

5   bars of each of said first and second optical character-

     istics; and

7   means for deriving from said pixel counters average

     narrow bar pixel counts.

             15. The system of claim 1, wherein said digital

     memory means comprises first and second serial memory circuits

3   connected to receive said digital data signals, and wherein

     said second logic means comprises memory selector means for

5   selecting only one of said memory circuits at a time for

     reception and storage of said digital data signals.

             16. The system of claim 15, said second logic

     means further including means for transferring stored data

3   out of said memories, said memory selector means including

     means for selecting only one of said memory circuits at a

5   time for transferral of data, said memory selector being

     operative to select one memory circuit for reception and

7   storage of data while selecting the other memory circuit

     for transferral of data.

17. The system of claim 16, wherein said first

logic means includes means responsive to said bar width

3   signals to detect an invalid code bar, and wherein said

second logic means including means responsive to an invalid

5   code bar to reset the memory circuit selected for reception

and storage of data.

18. The system of claim 17, further including

bar counter means for producing a bar count pulse when a

3   predetermined number of code bars have been scanned; and

means responsive to a bar count pulse to activate

5   said second logic means to inhibit the memory circuit

selected for reception and storage of data to prevent the

7   entry of additional data.

19. The system of claim 18, further including scan

detector means for detecting the end of a scan of a bar code

3   and for producing an end of scan pulse, said memory selector

means being responsive to an end of scan pulse for shifting

5   said memory circuits.

20. The system of claim 15, wherein said means

for producing a train of bar width signals includes a state

3 change detector responsive to changes in the state of said

filtered binary signal to produce a state change pulse each

5 time said filtered binary signal changes from one binary

state to another, and wherein said second logic means

7 includes means for applying said state change pulses to said

first and second memories to clock the memory selected for

9 reception and storage of data, whereby said selected memory

is advanced for each code bar, and receives corresponding

11 bar width data for storage, whereby the selected memory

receives and serially stores binary data representing the

13 width of each of the code bars in said bar code.

21. A method of reading bar codes and storing

binary data pulses corresponding thereto, comprising:

3   optically imaging a bar code having a plurality of

narrow and wide code bars of alternate first and second

5   contrasting optical characteristics on a linear array of

picture elements in a scanning camera;

7   producing an analog video signal corresponding to

the bar code image by sequentially scanning said picture

9   elements, said analog signal being comprised of a series of

pixels;

11   converting said analog video signal to a binary

video signal having a first level for code bars of a first

13   optical characteristic and having a second level for code

bars of a second optical characteristic;

15   filtering said binary video signal to eliminate

single pixel aberrations and to produce a filtered binary

17   signal having said first and second levels;

detecting changes in said binary signal levels and

19   producing corresponding state change pulses to indicate the

beginning and end of each of said first and second binary

21   levels;

driving a serial memory at a clock rate determined

23   by said state change pulses to advance said memory one step

for each code bar;

25   producing a bar width signal for each code bar,

said bar width signal having a first value for narrow bars

27   and a second value for wide bars; and

supplying said bar width signals in sequence to

29   said serial memory in synchronization with the stepping of

said memory by said state change pulses, whereby said bar

31   width signals are stored in said serial memory to provide a

serial record of the width of each code bar in said bar code.

22.   The method of claim 21, wherein the step of

producing a bar width signal comprises:

3   predetermining the number of pixels nominally in a

narrow code bar;

5   counting the number of pixels in each code bar; and

producing a bar width signal of said first value until

7   the number of pixels being counted exceeds the predetermined

number and thereafter producing a bar width signal of said

9   second value.

23. The method of claim 22, further including

the steps of:

3   supplying said bar width signals to a pair of

serial memories;

5   selecting one of said memories for receiving and

storing said bar width signals for a first bar code scan;

7   selecting the other of said memories for trans-

ferring stored data to data handling equipment during said

9   first bar code scan; and

reversing the selection of said memories for a

11   second bar code scan.

24. The method of claim 23, further including

inhibiting said memories at the end of each bar code scan to

3   prevent entry of spurious data.

25. The method of claim 24, further including

the steps of:

3   producing a clearing signal upon scanning an

invalid code bar; and

5   clearing the memory selected for receipt and

storage of bar width signals upon occurrence of said
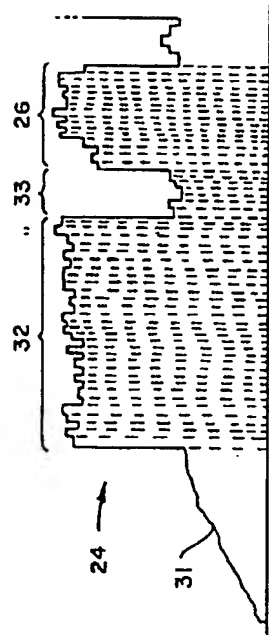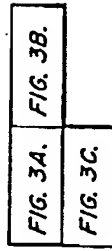
7   clearing signal.

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FIG. 1.

FIG. 6.

FIG. 5.

FIG. 3A.	FIG. 3B.
	FIG. 3C.

FIG. 2.

FIG. 3B.

FIG. 3A.

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F/G. 3C.

FIG. 4A.

FIG. 4B.

FIG. 4C.

FIG. 4D.

FIG. 4E.

FIG. 4F.

FIG. 4G.

FIG. 4H.

FIG. 4I.

FIG. 4J.

FIG. 4K.

FIG. 4C'.

FIG. 4L.

FIG. 4M.

FIG. 4N.

FIG. 4O.

FIG. 4P.
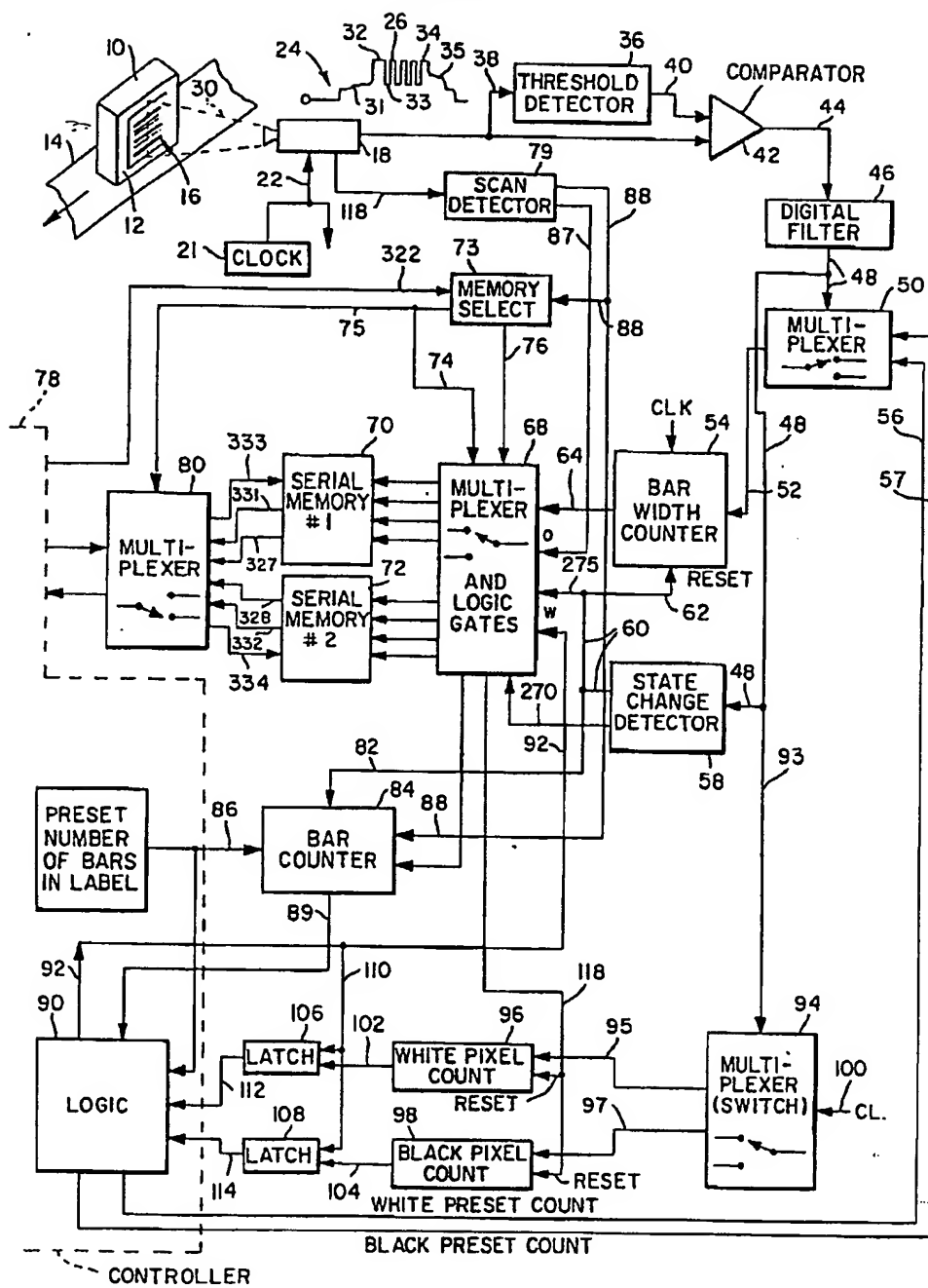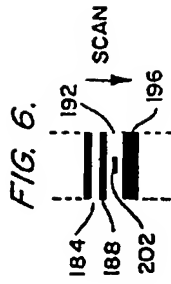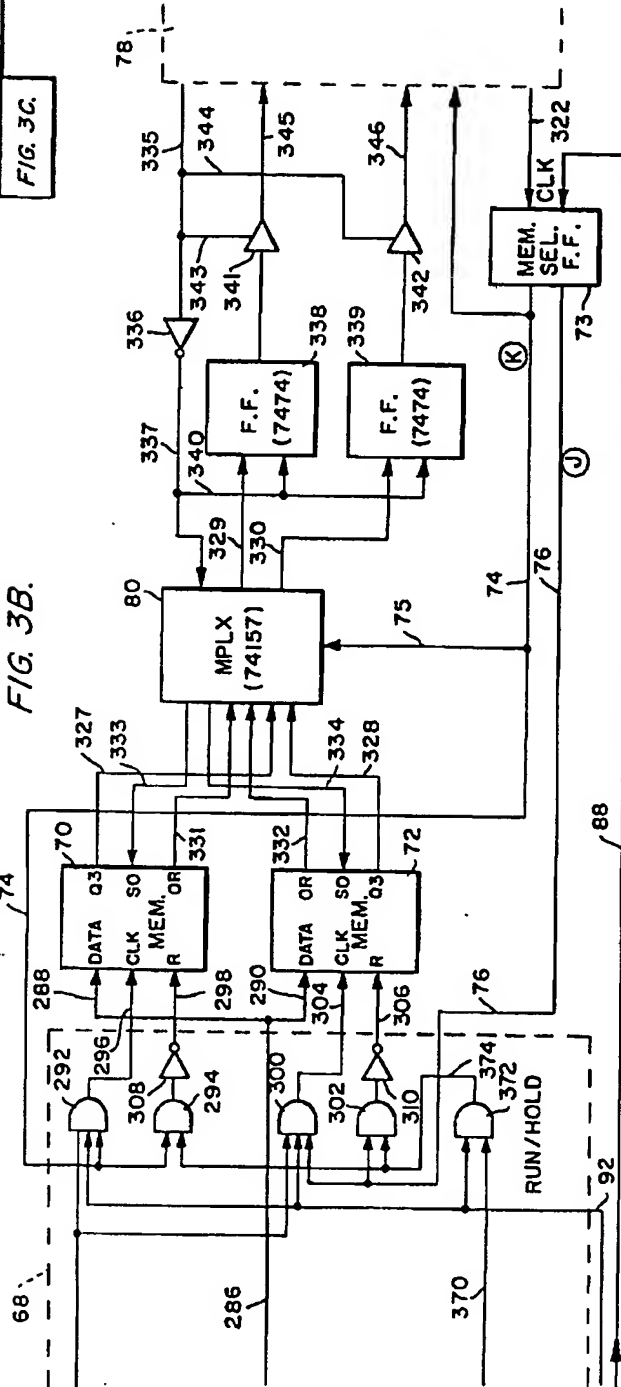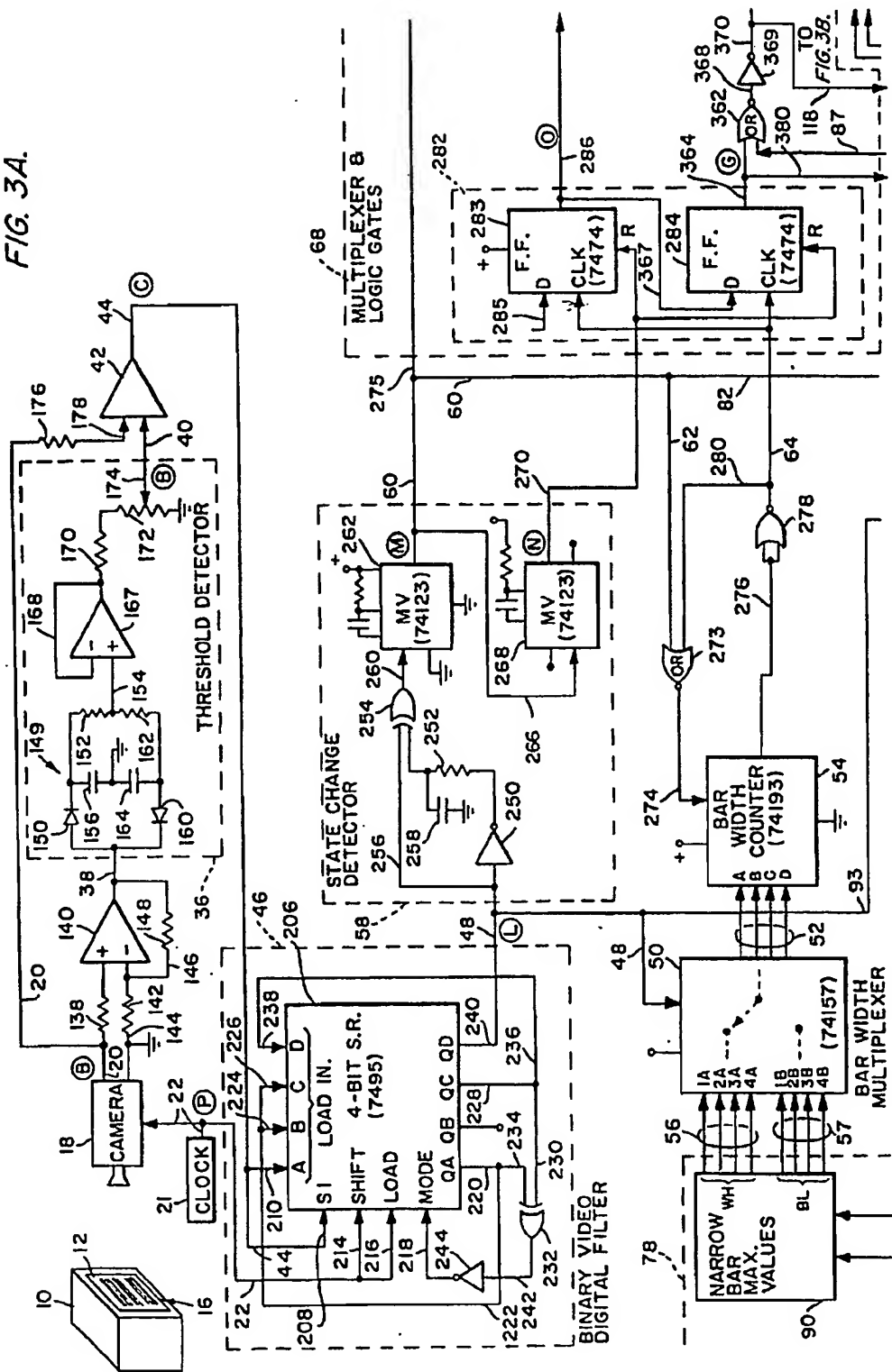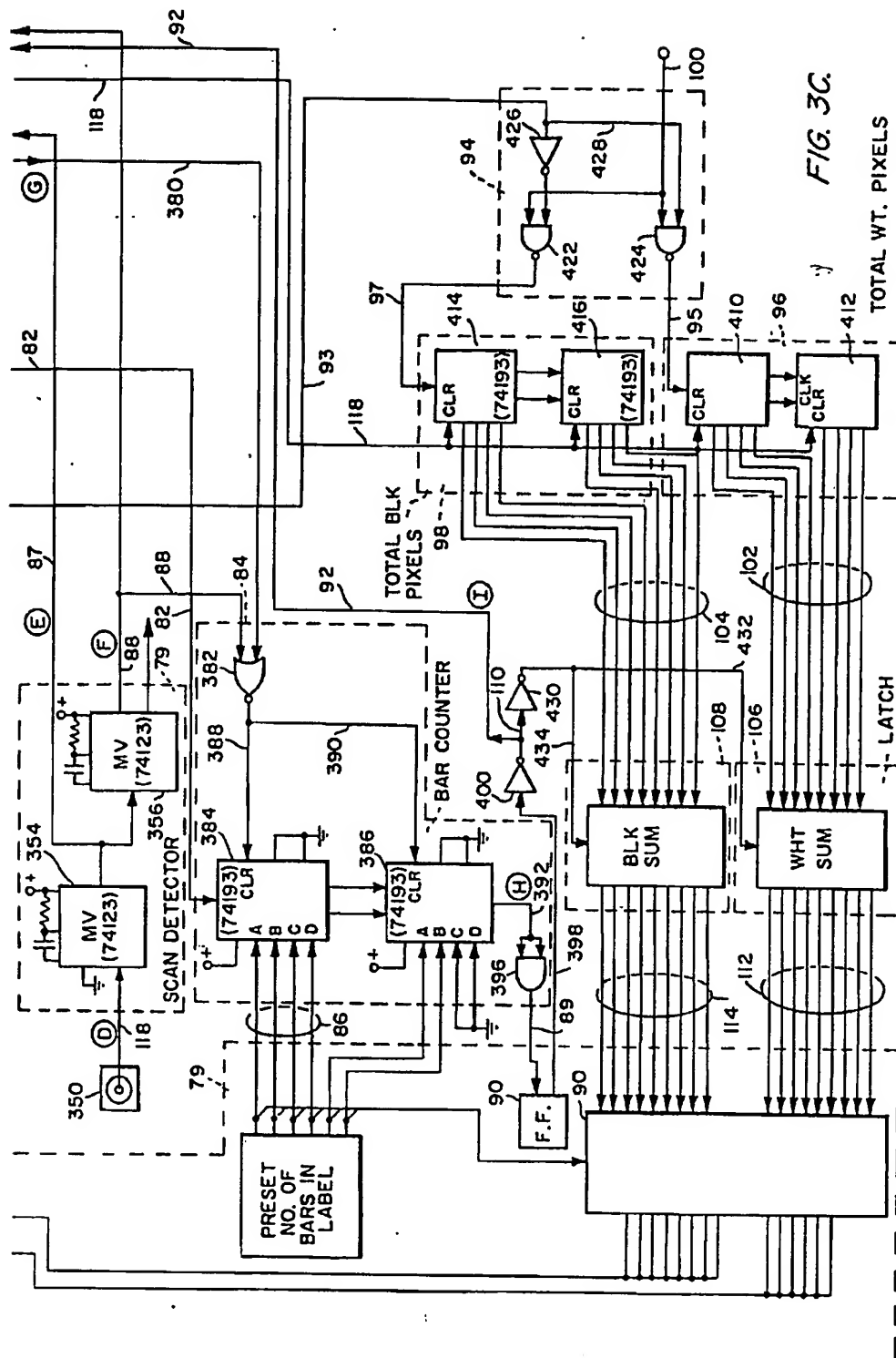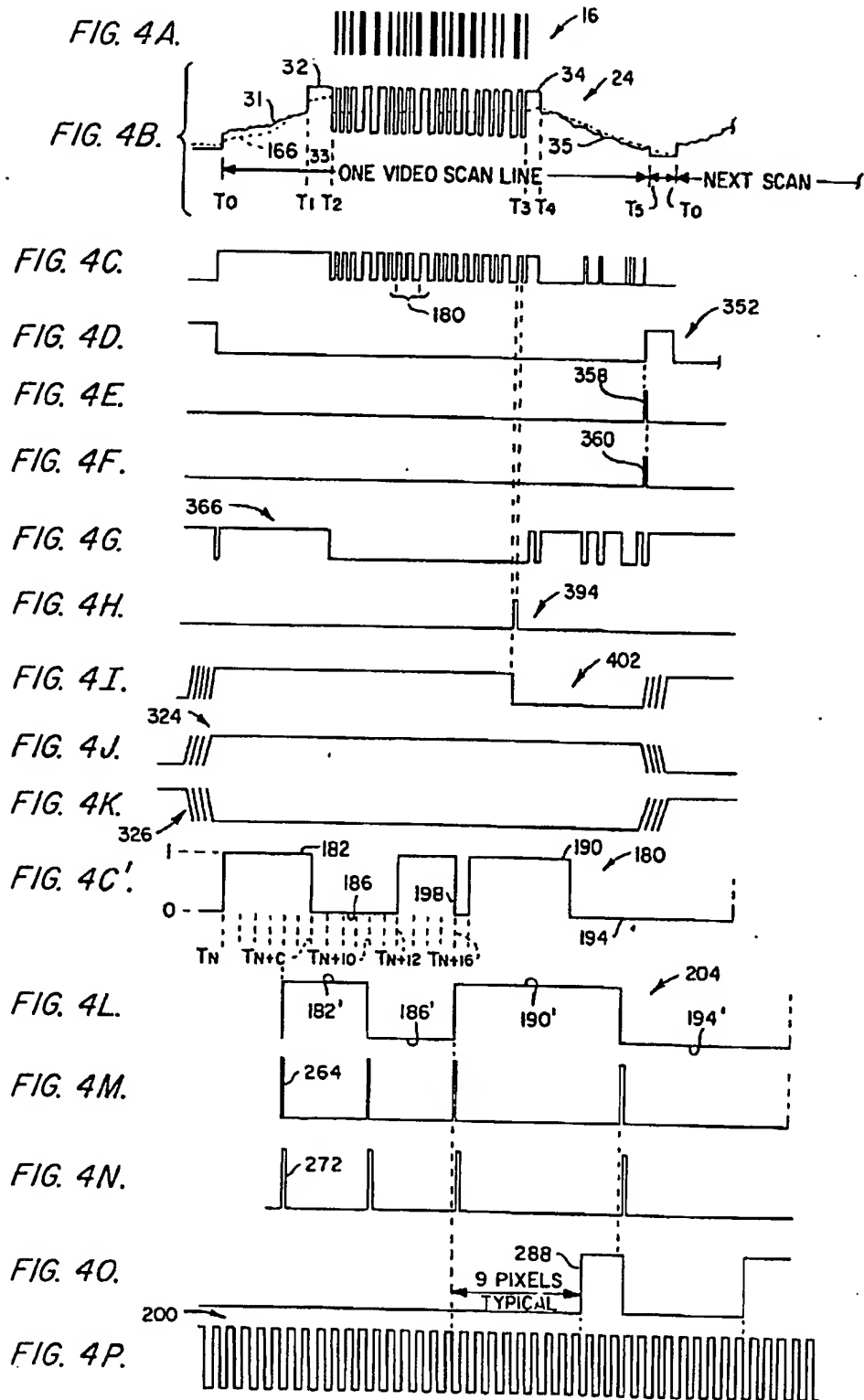
European Patent Office

EUROPEAN SEARCH REPORT

	DOCUMENTS CONSIDERED TO BE RELEVANT		CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with Indication, where appropriate, of relevant passages	Relevant to claim	
X	<u>US - A - 4 147 295</u> (NIPPONDENSO) * Figures 1-4; from column 1, line 53 to column 7, line 51 * --	1-3,5, 7,11- 14,21	G 06 K 7/016 7/14
	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 18, no. 3, August 1975, Armonk, US PIERCE: "Hand-wanded optical bar-code signal processor" pages 892-894. * Figures 1,3; page 893, 5th paragraph; page 894, lines 1-24 * --	1,4	
	<u>US - A - 3 927 303</u> (NIXDORF COMPUTER) * Figures 2,3; from column 8, line 14 to column 11, line 51 * --	1,8,10	TECHNICAL FIELDS SEARCHED (Int. Cl.³) G 06 K 7/016 7/14 7/10
	<u>US - A - 3 868 636</u> (ISOTEC) * Figure 16; from column 17, line 35 to column 18, line 13; from column 19, line 25 to column 20, line 44 * --	1,15, 16	
	L'ONDE ELECTRIQUE, vol. 44, no. 446, May 1964, Paris, FR ANDRE et al. "Analyseur multiparamétrique", pages 535-543. * Figure 4; page 5, left-hand column * -- ./.	15,16	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30-06-1981	FORLEN

EPO Form 1503.1 06.78

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	DOCUMENTS CONSIDERED TO BE RELEVANT		CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	DATAMATION, vol. 6, no. 1, January-February 1960, Barrington, Ill., US PORTER: "The RW-400-A new polymorphic data system", pages 8-14. * From page 13, right-hand column, last paragraph, to page 14, left-hand column, first paragraph * ----	15,16	
			TECHNICAL FIELDS SEARCHED (Int. Cl.³)